From Computational De-Morphogenesis to Contaminated Representation for the Contemporary Digital Tectonics and Lexicon

Vulnerability and Resilience of the Generative Representation in the Web-Oriented Platform – BIM/GD

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Abstract — The study illustrates a research project di “Digital Tectonics” and “Digital Lexicon” for the recognition and representation of pattern relating to architecture and Cultural Heritage in the Web-Oriented Platform – Building Information Modeling (BIM) / Generative Design of the Modifications. Among the research objectives there is: a) shape (through the dialogue between different 3D modeling and smart tool BIM), processes’s representation of codification and valorisation of the architecture; b) cooperation, sharing information (through an advanced 3D semantic ontological model of goods), knowledge’s monitoring (through typologies of representation). This through a methodology defined by Digital Layout of parametric libraries objects divided by category. The study allowed to highlight: a) hierarchy of digital levels and multimedia contents; b) creation of libraries of parametric objects; c) a semantic level of models at the level of detail; d) exchange of multidimensional information; e) transition from parametric representations to objects integrated into 3D Web.

Keywords — Digital Tectonics; Digital Lexicon; Recognition and Representation of Pattern; WOP–BIM/GD; De-Morphogenesis; Contaminated Representation

I. INTRODUCTION

The study illustrates a research project of “Digital Tectonics” (digital constructions) and “Digital Lexicon” for the recognition and representation of pattern relating to architecture and Cultural Heritage (CH) in the Web-Oriented Platform (WOP) – Building Information Modeling (BIM)/Generative Design of the Modifications (GDM); this because the current need in digital design is based on the customization of the tools to promote: a) a new digital lexicon; b) the generation and verification of the behavioral performance of architectural surfaces; c) a creative and rational model for the rapid generation and succession of changes occurring in the urban landscape in order to evaluate its compatibility with the design guidelines. The WPO-BIM/GDM will based on:

• Analysis and Conservation of Architectural Heritage;
• Provision, Processing and Data Transmission of Architectural Contents for the purpose of defining the spatial, decorative and aesthetic identity through communication layers; with the aim of examine in depth the following layer:

A. Digital Lexicon

• WP1 - Processes of Codification of the Architecture.
• WP2 - Shape through the dialogue between different 3D modeling and smart tool BIM.
• WP3 - Processes’s Representation of Codification and Valorisation of the Architecture. This in order to highlight: a) “Interpretative Values” of the spatial-architectural system in relation to the capabilities of identify new scenographic contexts; b) “Visual Model” of reading, classification, comparison interdisciplinary data and perceptive quality.
• WP4 - Achievement of Expressive Values in the Communication of Architectural Heritage.

B. Digital Tectonics

• WP5 - Cooperation, through multidisciplinary interaction, mutual relationship and shared on domains, comparison of data for the purpose of “digital recovery” of the same.
• WP6 - Sharing Information through an advanced 3D semantic ontological model of goods with adequate level of accuracy; intended as a cognitive system of structured models, regulated and identified by contents in 3D GIS for the topological control of forms.
• WP7 - Knowledge’s Monitoring through a multiscale e-learning database (DB) of 3D visualization in GIS environment articulated on typologies of representation of the knowledge divided by “Dynamic and Evolutionary”, “Non-Dynamic and Evolutionary”, “Post Digital”. This in order to highlight “Advanced 3D Semantic Ontological Model” with adequate level of accuracy (Figure 1).

These goals will allow to highlight: a) Regenerative synergies for the “empty spaces”; b) Phenomenological reading of the changing complexity of environmental reality according to Christian Norberg-Schulz (1926–2000) and Kevin Andrew Lynch (1918–1984); c) Hub solution of knowledge and simulcast description of information of CH.
This through Digital Layout (DL) of parametric libraries objects, that show “Lexicon of Representative Typology of Models”, are divided by category (type, reference, geometry and shape, visual appearance, dimensions and properties) in order to obtain: a) Exchange of multidimensional information with thematic detailed study; b) Transition from parametric representations to objects integrated into 3D Web through manipulation of intrinsic (dimensional, geometric, morphological and chromatic) and extrinsic data; c) Creation of 3D elements by geometry, semantic representation and appropriate correspondence.

In particular:

- Hierarchy of digital levels and multimedia contents discretized by 2D and 3D models interoperable and subdivided by dimensional categories and meanings.
- Creation of libraries of parametric objects based on point clouds divided by category, type, reference, geometry and shape, visual appearance, dimensions and properties.
- A semantic level of models at the level of detail.
- Semantic basis of construction, description and communication for all the elements involved in the process of developing the semantic Web.
- Critical considerations in the graphic representation.
- Representation of permanence signs, modifications and subsequent comparing data of different functional, historical, geometric, typological and structural categories with topological, photometric and geometric characteristics [1] (Figure 2).

For this reason the project is articulated on “De-Morphogenesizis” (D) of the landscape assets (understanding as deconstruction of the architectural and Landscape image) and subsequent reconstruction of the formal architectural and Landscape vocabulary (lexicon); this within a new vision of transformation, and of the intangible aspects linked to the Cultural Landscape. It will be understood as “Contaminated Representation” (CR), appropriate to represent the work and its space with the communication of modification processes occurring in time (that have contaminated the environment), and based on: a) Algorithmic methodologies of prototyping to experiment the provocative potential of the modifications occurred that invade the territories of thought and spatial planning; b) Diversification of 3D graphical models with innovative communication models of the contemporary experiments; c) Processes’s Representation of the Digital Tectonics and Digital Lexicon. In this context are evident the relationship between architectural space and optical illusion, transparent volume and force interpenetration, exaltation of dark tones and a widespread illumination, geometric construction and algorithm, experimentation and fusion of light with color for innovative chromatic surfaces.

The WOP-BIM, implemented through Autodesk’s A360 and BIM 360 (European Union Public Procurement Directive 2014/24/UE) will be:

- Implementable;
- Applicable for customized processes;
- Shareable in the cloud for all information;
- Articulated in DL, through thematic sections and divided by topic, of parametric libraries objects based on point clouds of Computational Design; as relational model (Big Data management, automated generation of shapes, complex geometries) will allow (through algorithms) to translate the complexity of information into data. This through the definition, in a visual environment, of parameters of various elements of the project, with attributes and relative correlation with other objects;

In the WOP-BIM there is the application “Generative Design of the Modifications” - GDM (direct transmission of computational design), intended both as a rational model (for the rapid generation of solutions), and as a creative one (for the variety of innovative solutions that the algorithms provide). This will allow, within the digital lexicon, a 2.0 generative representation for: a) the verification of the rapid generation and succession of changes in the urban landscape. This in order to evaluate the best compatibility with the design guidelines; b) the creation of unique and non-repeatable representations (forms), with possible design combinations through cloud computing; c) the interactive insertion of design’s forms or architecture in the urban context; d) the
evaluation of forms and structures (Figures 3, 4). This application can be configured as an innovative language of digital tectonics based on a model of “representation” intended as “simulation” for the generation of integrated systems - BIM / GDM; it can be vulnerable (easily modifiable) and resilient (to overcome the difficulties of the changes that have taken place: connectivity, digital content and services).

III. LINE METHODOLOGY OF RESEARCH

The relationship between DL and ontological classifications in the – Semantic Web field is very close; in fact, the DL favors detailed ontological representations for:

- Knowledge, categories, parameters and classifications;
- Clear and shareable information; according to Antoniou G. and Van Harmelen F., (2003), Intuitive, expressive and efficient;
- Quantity, type and subject of the conceptualization according to Van Heijst et al. (1997);
- Information (general requests), for knowledge modeling and representation (requests for form) according to Canfora et al (2004).

Therefore, the methodology of WOP-BIM/GDM is articulated on the following macro areas that contain the above layers (Figure 5):

- **Knowledge’s Ontology of Identities of the Architecture** (WP1 layer), based on criteria and conditions for evaluation of CH Assets in relation to a built space.
- **Knowledge’s Ontology of the Architectural Form** (WP2, WP3, WP4 layers), based on the formal aspect signs (plasticity of forms and subtraction of matter, transparency and visual illusion), the deconstruction of the architectural image (De-Morphogenesis), the recomposition of the formal architectural vocabulary in a new vision of transformation (On-Morphogenesis);
- **Ontology of Modeling Knowledge** (WP5, WP6 layers), based on study of sources, the arrangement, the relevant approach and integration methods of digital survey in order to define a one-3D system;
- **Ontology of Typological Representation Knowledge** (WP7 layer), based on CR and intended as “Diversification of 3D graphical models” and “Processes’s Representation of Valorisation of the Architecture” appropriate to represent the work and its space with the communication of modification processes occurring in time.

Fig. 3 – WOP-BIM/GDM Operative Scheme.

Fig. 4 - New Bocconi University headquarters in Milan - Grafton building (2008). Cloud Computing Platforms: Autodesk Fusion 360.
Landscape image (formal and constructive aspects); in addition the definition of same elements’s meaning following a new vision for proposes advances of interoperable models application. De-Morphogenesis concept, instead, acquires the results obtained by graphical analysis and proposes advances in the field of: 1) Graphic methodologies of Cultural Landscape’s identification. 2) Methods of digitization, detection and visual evaluation of the landscape and architecture's morphological features. 3) Interoperable models application for analysis and evaluation of heritage. 4) Communication of landscape modification processes for visual-perceptive regeneration as a remedy for urban degradation. It, besides considering:

A1 “Landscape Form Lexicon” through the following subcategories:

A1.1 “Representation Level of Landscape Elements’s Identity” for understanding of Entirety, Criticality and Vulnerability aspects with the following subcategories: a) “Physiotopes” in order to define different types of landscape; b) “Open Space” consisting of open spaces identification; c) “Anthropological Semiology” in order to define infrastructural, settlement, cultural, historical, architectural sign of arrangement, management of the historicized landscape and the articulation of the Urban and Rural Historical Landscapes of the environmental mosaic; d) “Absolute Visualisation” that allows the display of the great lines of the perceptible landscape about the overall set of morphological aspects present.

A1.2 “Visual Representation Level of Landscape with the Evaluation of the Morphological’s Characters”. In particular the study the forms of the ground, the distance and position of the observer according to Lynch and described by following subcategories: a) Visual Planes (succession of elements in the space); b) Visual Cones (distinguished by dimension, depth, orientation); c) Main reference points (useful elements for orientation and localization); d) Delimited Visual Scopes (limited and enclosed view) – (Figure 6).

A2 “Architectural Forms Lexicon” through the following subcategories:

A2.1 “Monumentality, Complex Forms, Plastic and Scenographic” through: a) plasticity of forms and subtraction of matter; b) recovery of the perspective space relationships and geometry; c) architectural-scenographic construction related to theatrical scenic illusionism in which the perspective method has provided the basis of the optical illusion; d) transparencies and visual illusion in the articulated monumental staircases; e) the turning “bibienesca” for corner's view; f) succession of different cuts of the stage with long and short scenes.

A2.2 “Mathematical Rule and Graduality of Spaces” through: a) lexicon matrix and geometric texture, a system of rules marked by mathematical and proportional relationships taken from the natural and pagan world. It is based on the circumference and the square (synonyms of heaven and earth), which in the Baroque will be associated with unity and perfection (in the case of the circumference) and to the trinity (in the case of the equilateral triangle and hexagon). Recurring is number 3. Criteria that Greg Lynn (1964) deems feasible with algorithmic numerical series.

A3 “Characters’s Anamorphosis Lexicon” through the following subcategories:

A3.1 “Architectural Representation Level of Characters’s Anamorphosis” through: a) “Graphic Lexicon Components” to highlight shape and tonal value, pattern, texture and background; b) “Chiaroscuro Lexicon Techniques” to obtain special effects with pencil, inks, charcoal and sanguine by regular and cross hatching, dot technique, frottage and graffito; c) “Chromatic Lexicon Technique” by the use of different color modes and colors in a monochrome design or in a scheme in which another one predominates (Figures 7,8);
d) “Application Areas of the Techniques” with connection to the architectural finishes (of elevation, section and perspective), to the centers of visual attention, to the spaces between elements, to the contrasting elements in a set of regular elements.

A3.2 “Architectural Representation Level of Syntax Morphological” through: a) “Formal Composition’s Analysis” (harmony, symmetry / asymmetry, modularity, rhythm, alignment, visual direction, movement, balance, proportion, visual weight, visual unity, visual contrast); b) “technological structure”.

A4 “Surface Lexicon” through the following subcategories:

A4.1 “Color, Surfaces and Matter” through: a) chromatic and material, based on currents of thought, distinction of elements, functional differentiation of spaces, symbolic and psychological meanings; b) materials and textures, based on innovative textures, methods of aesthetic and compositional treatments; c) light effects connected to chiaroscuro ones, for the visual rendering of shapes and profiles given by the combination of pure forms and visual lightness, chromatic uniformity; c) material transparency.

A4.2 “Color, Light, Landscape” through: a) color experimentation through the solutions: a) Bauhaus 1919-1933 (design combinations, according to Johannes Itten 1888 - 1967, for chromatic properties - red / white / black - and schemes geometric compositions by subdivision / tripartition, arithmetic and geometric succession, golden section – (Figure 9); or as Theo van Doesburg 1883 - 1931, through chromatic contrasts for primary colors or black and white, yellow and black with insertion of colored elements and multicolored objects, strong and contrasting colors, geometric patterns); b) Deconstructivism with design / chromatic innovations, passage to imbalance, chromatic-formal dynamism, to the instability of forms (tortuous, asymmetrical surfaces, sinuous lines, swirling spirals) and the use of primary colors (Figure 10); c) color, light and nature to combine, through design transparencies, shades of gray, light and nature within the projects (see Bauhaus headquarters in Dessau, teaching houses).

2. “Semantic Values of the Architecture by On-Morphogenesis with Perceptive and Symbolic References” through both a reconstruction of the formal architectural vocabulary (lexicon) in a new vision of transformation, and of the intangible aspects linked to the cultural landscape (Figure 11).

B. Ontology of Modeling Knowledge

The level considers the following categories:

B1.1 “Dimensional Representation Levels” with the following significance subcategories: a) “Study of sources, the arrangement of indirect survey techniques and the relevant approach of the survey”; b) “Study of the survey integration methods applied to the plan and the elevated parts in order to define a one-3D system”; c) “Selecting an appropriate 3D
acquisition methodology”; d) “Integrated digital survey and
data recording” to highlight the irregularities of the building
(Figure 12). It will be based on digital integrated survey (3D
laser scanner time of flight model Leica C10 ScanStation) and
Structure from Motion for data search of topography, laser
scanning, photogrammetry, H-BIM, matching the model and
the point cloud, designing parametric building elements.
Metrological and proportional analysis allowed for the
optimization of the modeling operations, and the knowledge of
the complex, just partially documented [2]. Or based on a
“Digital Hybridization” intended as photogrammetry of points
of interest, meshing of photogrammetries. This in order to
create models of interest, cloud point generation, compositing
of architectural elements, lighting, rendering (Figure 13); e)
“Dialogue between the different methods of analysis and 3D
modelling of the area of representation with the multiplicity of
data collected.

C. Ontology of Typological Representation Knowledge

The level contains critical considerations and elements of
innovation to highlight the differentiation data and the
modifications occurred [3] with a graphic representation
divided for:

- “Dynamic and Evolutionary knowledge” (in their
historical becoming) with simulation lexicon
(reconstruction process and digital restitution of
horizontal and vertical elements, overlapping data –
(Figures 14,15,16);
- “Non-Dynamic and Evolutionary knowledge” (at a
given moment, abstracting from their evolution over
time) without lexicon simulation (Figures 17,18);
- “Post Digital knowledge” (digital, virtual and online
technologies, digital image processing) - (Figure 19).

It is based on CR characterized by: a) evaluations through
rapid prototyping, linked to norms and performance
verifications; b) research and practice together, where the
mathematical structure of the visualization program becomes a
formal and structural process of the image-object; c)
algorithmic design methodologies to obtain new forms of
architecture. These experiments brought to the creation of a
new “architecture contaminated” by the provocative
possibilities offered by software that invade the territories of
the thought and spatial planning. In fact, a single algorithm
can generate an infinity of mathematical functions and
different shapes or surfaces. The construction of a prototype
occurs when the process is blocked by isolating the selected
snapshot from the sequence it belongs to. The production of a
sequence becomes the mass production of unique pieces of the
“non-standard” representation (mass-customization); d) a
capacity to illustrate the richness of the composition of the
landscape, the cultural and social dynamics of the
contemporaneity; e) complicated sculptural forms for the
diverse organizational systems present and intrinsic of
emotionalism, of sensationalism that escape from geometric
control. The multiplicity of irregular and surfaces lines attracts
the curiosity of matrix search.
The representation, starting from this design complexity, consists of:

**C3.1 “Innovative model of communication”** (Digital Transformation and Digital Metamorphosis) based on a complex design thinking in balance between transparent volume, force interpenetration, geometric construction and algorithm that can return a unique expression conclusive. The transparency of the volumes appears in line with orthogonal axonometries elaborated by the German Bauhaus German School of Art (1919-1933) to represent the functionalism of the regular forms of architecture. The transparency of the volumes appears in line with orthogonal axonometries elaborated by the German Bauhaus School of Art (1919-1933) to represent the functionalism of the regular forms of architecture (Figure 20).

**C3.2 “Spatial compartment of objects and decomposition of the line-force movement as in the futurist period. The feeling that comes out is of complex and contradictory forms.**

**C3.3 “Exaltation of dark tones and a widespread illumination”** to accentuate elongated shadows, as in Giorgio de Chirico’s work (1888-1978) – (Figure 21).
C3.4 “Limited representation of plan and sections” in communicative sheet, as they are considered secondary to the understanding of architectural forms.

C3.5 “Model representations, in perspective” (at a single viewing center) or in axonometric projection relevant for position and size. Spatial understanding is increased by rotation the model and subsequent visualisation in axonometric projection (from top to bottom and from bottom to top). As in the expressionism of “Italian rationalism” of the “Italian Movement for Rational Architecture” (MIAR) of the 1930, where the axonometric vision is understood as the conclusive representation of the design process, comparable to the wooden model, presented with view from top to bottom (to identify with the wooden model of the past), and from bottom to top (replacing accidental perspective representation as it is considered a non-rational visual interpretation). Limited works of MIAR are represented in perspective, as those of Giuseppe Terragni (1904 - 1943), for the understanding of space (Figure 22).

C3.6 “A creative methodology that starts from the volumetric model to reach the mathematical model” on which to realize detailed studies in the project. The methodology remembers that applied by Renaissance architects who, at the initial phase, elaborated drawings for the realisation of wooden study model. On this, after made the necessary changes, plans, elevations and cross and longitudinal sections were executed. In fact, for Alberti in architecture an idea, or “drawing”, could only be realised through a model that was not a means of representation, but a tool for the realisation of the idea itself. Already in the last century, American architects have been innovative in the representation/communication of architecture and landscape (Figure 23).

In particular:
1) The representation of the drawings of 1700 and 1800 is composed of distributive plans (with shadows according to the indications of French masters) and pictorial elevation drawings with sculptural ornaments, according to “Georgian Style”, for the intuition of the third dimension. The Perspective, after 1820, will be indispensable to relate the volume to nature and the site as in the case of Richard Upjohn (1802 - 1878).
2) Between 1860 and 1890 architectural studies will produce drawings according to publications for professional purposes and sale of the product with three types of drawings: communication, presentation and execution. Among perspectives (height-man), unlike the past, there are those of Frank Furness (1839-1912), conceived as a union between visual representation and presentation. Map and prospect drawings, according to the influence of Beaux-Arts, will feature planimetric composition representations, while the landscape will go to the background. Frank Lloyd Wright's drawings (1867-1959) will be an exception in which plan drawing predominates in design with attention to landscape and nature.
3) Between the First and Second World War due to changes in professional practice, spray technique will be used because of designers were expensive.
The drawings by Hugh Ferriss of Modernists Richard Josef Neutra (1892-1970) and Rudolf Michael Schindler (1887-1953) influence design with accurate drawings. Ludwig Mies van der Rohe (1886-1969) with the use of axonometric projection and photomontage will assert a “conceptual” and “structural” representation to the disadvantage of the perceptual. This to facilitate modernist principles. Even Skimidore, Qwing and Merill (a study founded in 1936) encouraged the use of axonometric projection and cardboard scale model with the supremacy of the plan drawing carried out through axis of symmetry. Louis Isadore Kahn (1901-1974) with rediscovery of the value of drawing as a means of knowledge and communication; 4) the drawings, since 1970, will highlight an executive component for the request of environmental impact.

C3.10 “Color combinations Simulation and Photorealism”, based on visual stimuli similar to those produced by reality linked to the lexicons; a) variations of luminescence through the theory of the tristimulus (light sources, materials and lighting model); b) global illumination through Ray-Tracing models (specular reflections of light) and Radiosity (diffuse reflections between surfaces).

VII. RESULT AND CONCLUSION

The study based on “Digital Tectonics” (digital constructions) and “Digital Lexicon” for the recognition and representation of pattern relating to architecture and CH in the WPO – BIM/GDM solution allowed to highlight: a) hierarchy of digital levels and multimedia contents discretized by 2D and 3D models interoperable; b) Transition from parametric representations to objects integrated into 3D Web; c) creation of libraries of parametric objects based on point clouds divided by category, type, reference, geometry and shape, visual appearance, dimensions and properties.; d) a semantic level of models at the level of detail; e) exchange of multidimensional information; f) transition from parametric representations to objects integrated into 3D Web; g) Critical considerations in the graphic representation; h) Representation of permanence signs, modifications and subsequent comparing data of different functional, historical, geometric, typological and structural categories with topological, photometric and geometric characteristics [1]. This was possible through a research methodology based on: a) “De-Morphogenesis” of the landscape assets (understanding as deconstruction of the architectural and Landscape image); b) “Contaminated Representation” appropriate to represent the work and its space with the communication of modification processes occurring in time (that have contaminated the environment). It is based on the subsequent recomposition of the formal architectural and Landscape vocabulary (lexicon); this within a new vision of transformation, and of the intangible aspects linked to the Cultural Landscape.

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